Fuzzy Regression for Electrical Resistivity—Hydraulic Conductivity Relationships

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General properties and a solution methodology for fuzzy regression are derived and illustrated using a relationship between soil electrical resistivity and soil permeability. Fuzzy regression can be used when a relationship between variables can be assumed at a given level of credibility but the available small number and/or the inaccuracy of the corresponding data do not allow use of traditional regression analysis. Techniques of fuzzy linear regression are extended to nonlinear cases. Regression parameters considered as fuzzy numbers are calculated by minimizing so-called vagueness criteria that correspond to the least squares criterion in traditional regression analysis. Several alternative measures of vagueness are introduced. For linear fuzzy regression, linear programming can be used to calculate regression parameters. The methodology is used to define a nonlinear relationship between soil resistivity and permeability based on six calculated resistivities and six measured permeabilities. For the present case, the so-called prediction vagueness criterion leads to a more robust fuzzy regression than the maximum or average vagueness criteria. The way in which the fuzzy regression obtained can be utilized to estimate the permeability field of a soil liner serving for waste containment and groundwater protection is discussed.

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Approximate Fuzzy C-Means (AFCM) Cluster Analysis of Medical Magnetic Resonance Image (MRI) Data

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Application of an "approximate" fuzzy C-means (AFCM) clustering algorithm as a data dimension reduction approach to medical magnetic resonance images (MRI) is described. Image data were one T_1-weighted (TE = 25 ms, TR = 600 ms) and two T_2-weighted (TE = 40 and 80 ms, TR = 2000 ms) images in each case, obtained with a 1.5-imaging system (GE Signa). Analyses were performed on 98 cranial MRI image sets with a variety of cerebral pathologies. The cluster analysis was operated in an unsupervised mode, and computational complexity was minimized by utilizing a table look-up approach without adversely affecting accuracy. Image data were first segmented into two coarse clusters, each of which was then subdivided into 16 fine clusters. The final tissue

classifications were presented as color-coded images and as two- and three-dimensional displays of cluster center data in feature space. Fuzzy cluster analysis proved to be a clinically useful dimension reduction technique that resulted in improved diagnostic specificity of medical magnetic resonance images.

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A Fuzzy Logic Programming Environment for Real-Time Control

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Expert systems based on fuzzy logic inferencing have been shown to be effective in controlling complex processes. The experiences of human operators are naturally captured as linguistic fuzzy control rules. This paper describes a programming environment being developed to facilitate the implementation of fuzzy control systems that allows a user to easily describe a set of fuzzy rules, graphically edit the fuzzy variable definitions, and verify the rules through simulation.

In an actual control system, the rules will reside in and be processed by a special-purpose chip for fuzzy logic inferencing. An object-oriented approach to the programming environment naturally models this hardware architecture. Each set of rules is associated with a chip object simulated in software. The content of the chip object is changed as the rules are modified. When the simulation results are satisfactory, the content of the simulated chip can be copied directly into the hardware chip for real-time applications. A complex controller that involves multiple domains of expertise can be developed by first focusing on component chip objects and then interconnecting the components. The ability to translate linguistic rules into practical implementations is a unique and useful feature of this environment.

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Reliability of Existing Framed Structures Using Fuzzy Sets

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A rational approach through the applications of classical probability and statistical theory has greatly enhanced the assessment of structural safety. Although the studies conducted in this area are comprehensive and well developed, classical set theory still fails to provide adequate representation of some parameters; for instance, workmanship and deteriorated condition are observed by engineers and reported qualitatively. In the area of structural system reliability, studies have been concerned primarily with the load space, material properties, and dimensions, which are objective (quantitative) information. Recent research has demonstrated that imprecise (subjective or qualitative) information can have significant adverse effect on structural safety. Studies in medicine, economics, and engineering have also shown that fuzzy set theory may indeed by a useful tool for the